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Office Memorandum • UNITED STATES GOVERNMENT

TO : Chief, SP

DATE: 6 August 1956

FROM : SP/A

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SUBJECT: Status Report on Inverse Loran.

1. The equipment has been delivered and appears to be about as complete and functional as anticipated.

2. Much time could be spent berating the contractor on quite a number of points--such as fingerprints etched into the camera lenses, wiring fouling the camera shutters (rendering them inoperative), completely inadequate darkroom facilities, poor accessibility to all equipment for maintenance (requiring going outside of the trailer and standing on a ladder). However, the cameras have been repaired, the missing tools and equipment needed for operation are being requisitioned (such as chairs, clocks, timers, thermometers, safelights, typewriters, tool kits, and coffee pots, and it is possible, if inconvenient, to service the equipment.

3. Very little comment is needed on the antenna systems, which are nearing completion--the masts [redacted] are up and guyed. The antennas should be erected shortly. Sixty foot Trylon towers may be a useful adjunct for an NCS in this project--but is hardly a requirement for an outstation. The contractor had furnished 7 towers for the NCS in this project. One 60 foot tower for each end of three horizontal antennas and a separate vertical antenna for the signal receiver. The vertical antenna is a two section telescoping affair with the top section out of pipe. It can be erected in one piece and the pole is light enough so that a man can pick it up with one hand. This was shipped in the truck. The number of masts erected for the NCS is three. Plans now call for a folded dipole for transmitting, erected between two of the masts and a horizontal erected between one of these masts and the third mast. The receiving antenna (in place of two) for the timing receivers (which will be paralleled) will be strung parallel to the transmitting antenna between ropes. These ropes will be dead-ended on the masts supporting the transmitting antenna and spliced together and fed through the pulley on the third mast. A section of one of the support rope will be replaced by the antenna for the signal receiver. Three masts are surplus to the project. The ELINT branch has already requested these for the erection of the SO radar antenna set [redacted]

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Four masts were provided for [redacted] These will be erected and any surplus to our needs can be put to good use down there according to the O&T man stationed there. 50X1

4. Of a little more serious nature--the best information that the contractor is able to furnish about the time that the timing signal is the equipment indicates that there is a variation of about 3 microseconds. This seems to be due to variation of gain and the point at which the equipment recognizes that there is a pulse present. Even more disturbing is the fact that the contractor finds about 30 microseconds difference between the zero-distance round-trip times between the NCS and each outstation. Since the outstations are supposed to be identical, and no reason is offered for this difference, I am at a loss to account for it. It does not contribute to a glowing confidence in the contractors ability to make accurate time measurements in the first place.

5. Fortunately, as long as we are able to operate via the E layer for the timing channel and take a number of test shots on known stations, it should be possible to make a reasonable determination of what the delays within the equipment are.

6. On the reduction of the data: The films may be developed locally in the trucks and taken to [redacted] for projection. Possibly a better site can be found at [redacted] but no effort has been made along that direction. Concurrence has been obtained from SP/EA for part time use of their projectors and facilities. The process of reducing the data to numbers consists in projecting each film in a still projector against a target ruled with vertical lines. Some point on the unknown signal will be taken for a reference, and the elapsed time from the first timing pulse will be measured, using the pulse spacing of the timing train as a yardstick. After subtracting out the time taken for the pulse train to travel from the NCS to the outstation, the remainder is a relative time of arrival of the signal at the station in question. Since these values do not correspond to anything in the real world they must be subtracted one from another to give difference in time of arrival. The end product of the equipment and data reduction on the film is to produce two independent numbers which are "how much later the second and third stations received the unknown signal after the first station." 50X1 50X1

7. The last step in the process represents a rather formidable mathematical problem to work analytically. A serious attempt was made to solve it, but no practical analytical solution could be found.

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As a result a method was devised somewhat similar to practical attacks on higher order algebraic equations when a numerical answer is required. Monographs and curves have been computed and drawn and [redacted] who assisted in their preparation has been briefed in their application. 50X1

8. The details of the systems follow: (Primarily because they have not been set down in writing elsewhere). [redacted] an engineer working on another contract, devised a particularly useful graph relating ground range, ionosphere height, and the slant height to the reflection point. On this graph all curves of constant slant height are straight lines and, further more, have the same slope. This permits direct utilization of Difference of Time of Arrival in an approximation method. One line is laid off at the proper slope permanently on an overlay. For each problem two additional lines are laid off on the overlay parallel to this one spaced by an amount corresponding to the difference in arrival time. This prepared overlay is then slid along the chart and corresponding ground ranges are read in great circle degrees at an assumed ionesphere height. Five trial readings are taken. It remains to determine if these ground ranges, when laid off from the appropriate I. L. Station will meet in a point. Two nomographs have been devised that will solve the spherical triangle on the surface of the earth bounded by two of the ground ranges and the known distance between the I. L. Stations. Two of these triangles are involved. The nomographs give the angle bounded by one ground range and a great circle between two of the I. L. Stations. These two angles when added should equal the difference in azimuth between the two great circles joining the stations of the network. This signed (algebraic) defect in meeting this condition is termed a residual and is a criterion of the three ground ranges meeting in a point. By this method a residual is determined for each trial setting on the original chart. These five residuals are tabulated against the original chart. These five residuals are tabulated against the five values obtained for any one given ground range. Then an inverse La Grange interpolation for a zero residual is performed to give a most probable value for one of the ground ranges. This value of ground range is taken to the original chart and at the same ionsphere height corresponding values for the other two ground ranges are determined. This must be again checked for meeting in a point. If they fail to meet satisfactorily another value of the ionsphere height must be chosen. This sounds like a lot of very complicated work. All of the computation is to be performed on charts and nomographs except the inverse La Grange interpolation. This is pure arithmetic (and not too laborious) it could, if necessary, be performed on a Friden calculator without taking any intermediate answers from the machine. References on the method are available in any good text on numerical methods, such as the Calculus of Observations, Whittaker and Robinson.

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As an alternative, the ground ranges could be checked on a map for meeting in a point. A Lambert Conformal Conic projection is suitable for this purpose. Loran charts cannot be used for this type of work dealing with the F layer unless one is willing to go to the labor (and expense) of drawing them for every layer height likely to be involved and for every prospective operating site.

9. In summary the work remaining to be done consists of the following:

A. Recheck the contractors equipment delay time measurements.

B. Construct and string up the antennas.

C. Have the Out Station truck delivered.

D. Train the men who will operate the outstation in what they must do.

E. Work out the operating schedule for the network.

F. Make a last minute check on completeness and proper functioning of the equipment.

An optimistic estimate for the completion of these items is about two to three weeks.

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[redacted] in absence of [redacted]

Distribution:
O&2 - Addressee
1 - Chrono

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ILLEGIB

[redacted]

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Pls file this STAT
in [redacted] folder. STAT

Pls inform [redacted]
[redacted] STAT
that:

(1) We will make
the delay measurements

(2) I will return
the "draft" papers
early next week.

(3) [redacted] can go STAT
ahead & print the [redacted] STAT

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(SENDER WILL CIRCLE CLASSIFICATION TOP AND BOTTOM)

CENTRAL INTELLIGENCE AGENCY

OFFICIAL ROUTING SLIP

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TO		INITIALS	DATE
1	[redacted] -SPD		11 Aug.
2			
3			50X1
4			
5			
FROM		INITIALS	DATE
1	[redacted] R+D-EP		50X1
2			
3			

☐ APPROVAL ☐ INFORMATION ☐ SIGNATURE

☐ ACTION ☐ DIRECT REPLY ☐ RETURN

☐ COMMENT ☐ PREPARATION OF REPLY ☐ DISPATCH

☐ CONCURRENCE ☐ RECOMMENDATION ☐ FILE

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